REMARKS

The Applicant thanks the Examiner for the prompt and thorough Office Action dated August 28, 2002.

The Examiner rejected claims 1, 7 and 8 under 35 U.S.C. §103(a) as being unpatentable over *Lin, et al.*, in view of *Trivedi, et al.,* and further in view of *Chang.* The Applicant respectfully traverses this rejection. The Examiner's argument supporting the rejection appears to be a piecemeal analysis of cited patents, which do not suggest the combination presented by the Examiner.

Applicant admits that *Lin* discloses generally the formation of a tungsten plug within a semiconductor topographical structure. *Lin* discloses a metal layer 202 presumably formed on a wafer substrate. One or more dielectric layers 204 are formed over the metal layer 202 and an organic material layer 206 is deposited over the dielectric layer 204. Reference 208, depicted in FIG. 2, represents additional dielectric layers 208. The topographical structure is formed within layers 208, 206, 204 to the metal layer 202.

Contrary to the Examiner's statement, *Lin* does not use a tungsten silicide and titanium compound as the first and second barrier layers, respectively. The metal layer 210 formed in the topographical structure of *Lin* is preferably composed of titanium, titanium nitride or a titanium/titanium nitride bi-layer formed by a physical vapor sputter deposition. A tungsten silicide 222 is formed over the metal layer 210 as shown in FIG. 2A by a chemical vapor deposition procedure. In contrast, the invention claimed in the present application provides

that tungsten silicide be formed, or deposited, within a recess formed on semiconductor device. Then tungsten is formed, or deposited, over the tungsten-silicide film to form the barrier layer of the present invention. Moreover, *Lin* does not disclose the three-film composite barrier layer as disclosed in claim 8.

The Examiner has similarly misinterpreted the *Trivedi* reference. Specifically, the Examiner has stated that *Trivedi* discloses the use of a tungsten and tungsten silicide as the first and second barrier layers, respectively, formed within a recess on a semiconductor device. The Examiner's attention is directed to columns 6, lines 46 through 67 and column 7, lines 1 through 15. *Trivedi* discloses a process for filling a recess 40 formed in a silica layer 36. A first diffusion barrier layer 42 functions as an adhesion layer for materials formed thereon. The barrier layer 42 is substantially composed of refractory metals or a nitride thereof, such as titanium, tungsten, tantalum, titanium nitride, tungsten nitride or tantalum nitride. Most preferably, the diffusion barrier 42 is substantially composed of titanium. The second barrier layer 44 of *Trivedi* is composed of a refractory metal or nitride thereof, such as titanium, tungsten, tantalum, titanium nitride, tungsten nitride or tantalum nitride. Most preferably, composed of titanium nitride.

Trivedi does not disclose the use of tungsten silicide as the first film of a barrier layer, or the combination of tungsten silicide as a first film and tungsten as a second film to form a composite barrier layer for a tungsten plug.

With reference to column 7, lines 48 through 67 and column 8, lines 1 through 13, *Trivedi* discloses a structure 70 formed over gate stacks 25. Once the gate stackts 25 are formed, a first barrier layer 30, which is comprised of titanium nitride, is formed using conventional sputtering. A first electrically conductive layer 32 is then formed over the first barrier layer 30. The electrically conductive layer 32 consists of tungsten or tungsten silicide, preferably tungsten formed using a chemical vapor deposition process. The second barrier layer 84, comprised of titanium nitride, is then formed over the electrically conductive layer 32. The first barrier layer 30 and the second barrier layer 84, in combination with the electrically conductive layer 32, form the local interconnect structure. Thus, the electrically conductive layer 32 does not serve as a barrier layer as suggested by the Examiner, but instead the conductive layer 32 serves as a contact between the metal-filled recess and the active area in the semiconductor substrate.

In the present invention, the combination of the tungsten silicide and tungsten films, respectively, serve as a barrier between the tungsten plug filling a recess and an insulating and/or dielectric material within which the recess is formed. Tungsten does not effectively adhere to dielectric materials, for example, so tungsten silicide is first deposited in the recess, and the tungsten film serves as a nucleation site for the tungsten plug. Moreover, the use of tungsten fluoride, for the sputter deposition of tungsten on prior art films such as

titanium or titanium nitride, may form "volcanoes" that cannot be removed by etchback procedures. This reduces the percent yield of semiconductor wafers.

With respect to the *Chang*, Applicant admits that *Chang* discloses a sputter deposition process for the deposition of tungsten and/or tungsten silicide in a semiconductor device; however, *Chang* does not suggest, nor do the other cited references suggest, the use of sputter deposition for deposition of tungsten-based layers. The cited references of *Lin* and *Trivedi* each disclose deposition of tungsten or tungsten silicide as barrier layers or a conductive layer using a chemical vapor deposition.

Moreover, the conclusions set forth on page 3 by the Examiner indicate that the Examiner does not understand the claimed invention. The Examiner stated that, "[It] it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a tungsten first barrier layer and include substrate in order to have a more reliable interconnect structure." The claimed invention does not claim tungsten as a first barrier layer. Tungsten does not adequately adhere to insulating dielectric material; therefore, a barrier layer is preferably formed to provide a basis for adhesion, and a nucleation site, for a tungsten plug. The first film of the claimed barrier layer is tungsten silicide – not tungsten.

With respect to claims 2 – 5 and 9 - 12, the Examiner found these claims obvious under 35 U.S.C. §103(a) over *Lin* in view of *Trivedi*, further in view of *Chang*, further in view of *Cadien, et al.*, and further in view of *Asahina, et al.*

Applicant's comments above with respect to the *Lin, Trivedi* and *Chang* references apply to the rejection of claims 2-5 and 9-12. The Applicant admits that the *Cadien* reference discloses a method of forming a tungsten contact, which includes forming a recess within a dielectric material. In *Cadien*, a tungsten silicide adhesion layer is conformally formed within the recess along its side and over the conductive metal layer. The tungsten silicide is deposited using chemical vapor deposition.

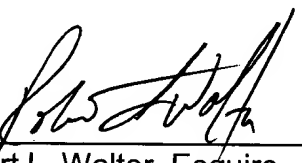
In the present application, at least with respect to claims 4, 5 and 9 – 11, sputter deposition of tungsten silicide and/or tungsten is claimed to deposit the films of the barrier layer. Claim 12 includes a system that includes a chamber and "means, associated with the chamber, for generation of plasma within the chamber..." *Cadien* does not disclose the sputter deposition, or a mechanism for generation of a plasma within the chamber. In as much as *Cadien* utilizes CVD, *Cadien* does not disclose the use of a tungsten silicide target or tungsten coil as required in claim 12.

With respect to claim 3, the present application discloses a tungsten silicide gradient within the tungsten film; and, claim 11 discloses the step of forming the tungsten silicide gradient within the tungsten film. The Examiner never addressed the limitation in rejecting claims 3 and 11. Moreover, the cited references do not disclose such an element, or remotely suggest that the references can be combined or modified to arrive at the element of forming a tungsten silicide gradient within the tungsten.

Applicant admits that *Asahina* discloses the deposition of a barrier layer using sputter deposition. In *Asahina*, oxygen is introduced into gaseous chamber for reaction with a target metal, such as titanium, to form titanium oxide barrier layer. However, *Cadien* and *Asahini* do not suggest that the sputter deposition mechanism can be used for the deposition of tungsten silicide or tungsten films.

Applicant respectfully requests the Examiner to reconsider the rejection based in the cited references. In view of the foregoing comments, the Applicant submits that claims 1 through 16, as amended are allowable. If further prosecution of this application can be facilitated via telephone conference, the Examining Attorney is invited to contact the undersigned at (407) 926-7706.

Respectfully submitted,



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I hereby certify that a true and correct copy of the above and foregoing Amendment was furnished by First Class Mail to the Commissioner of Patents, Box Non-Fee Amendment, Washington, DC 20231, on this 26th day of November, 2002.

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CLEAN VERSION OF THE AMENDMENT

IN THE SPECIFICATION:

Please amend the specification as follows:

IN THE CLAIMS:

Please amend the claims as follows:

1. (Amended) An interconnect structure, comprising:

(e) a substrate having disposed thereon a topographical structure including a dielectric material and a recess formed therein;

(f) a tungsten silicide film disposed along a surface of the recess;

(g) a tungsten film overlaying said tungsten silicide film; and,

(h) a tungsten plug deposited within the recess on said tungsten film.

12. (Amended) A semiconductor manufacturing system comprising:

(a) a chamber within which sputter deposition is performed;

(b) a tungsten silicide target mounted in the chamber;

(c) a tungsten coil mounted in the chamber below the tungsten silicide target;

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(d) a pedestal adapted to support the semiconductor source, positioned below the tungsten coil; and,

(e) means, associated with the chamber, for generation of a plasma within the chamber above the surface of the semiconductor device.

Please add the following new claims:

17. (Added) A method for forming a tungsten plug on a semiconductor device having a dielectric material formed over a substrate and a recess formed in the dielectric material, and said tungsten plug to be formed within the recess, the method comprising the steps of:

(a) conformally depositing tungsten silicide to a substantially uniform predetermined thickness along walls of the recess to form a first film;

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(b) conformally depositing tungsten to a substantially uniform predetermined thickness over the tungsten silicide within the recess and, after said tungsten silicide reaches said predetermined thickness thereof to form a second film;

(c) depositing tungsten silicide within the recess while said tungsten is being depositing within the recess thereby forming a tungsten silicide gradient within said second film; and,

(d) depositing tungsten within the recess over the second film to form said tungsten plug.

18. (Added) The method of claim 17 wherein said tungsten silicide of the first film is deposited within the recess at a predetermined deposition rate, and said method comprises the step of reducing the rate of deposition of the tungsten silicide for the first film at about the same time as, or after starting the deposition of tungsten for the second film within the recess.

A3 Cont.

19. (Added) The method of claim 18 further comprising the steps of providing a chamber within which the deposition of the tungsten silicide and tungsten takes place; positioning the semiconductor device within the chamber; providing a tungsten silicide target and a tungsten coil within the chamber; and, generating a plasma within the chamber adjacent the semiconductor device for the sputter deposition of tungsten silicide from the target and the sputter deposition of tungsten from the coil.